Atrioventricular Nodal Reentrant Tachycardia Ablated From Left Atrial Septum

Clinical and electrophysiological characteristics and long-term follow-up results as compared to conventional right-sided ablation

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SUMMARY

Radiofrequency catheter ablation or modification of the slow pathway is almost always performed on the right atrial side of the interatrial septum, however, this is not possible in rare cases. We evaluated the clinical and electrophysiological characteristics and long-term follow-up results of patients whose AVNRT could only be ablated from the left posterior atrial septum after repeated unsuccessful attempts on the right atrial side and to observe if they differ from those undergoing ablation with the conventional right-sided approach.

Of 587 cases with symptomatic typical AVNRT, 9 patients (1.5%) in whom RF energy delivered to the right atrial septum with the integrated approach failed to ablate or modify the slow pathway were enrolled in the study group (group 1) while the others served as controls (group 2). There was no significant difference between the groups regarding clinical characteristics, dual AV nodal physiology, sinus cycle lengths, AH and HV intervals, procedural complication rates, or recurrence rates in the mean follow-up duration of 34 ± 11 months. Only tachycardia cycle length (TCL) was significantly higher in group 1 than in group 2, which was mainly due to the difference in AH intervals ($P < 0.001$ for both). Slow pathway ablation was performed at the posteroseptal aspect of the mitral annulus in 6 and the midseptal aspect in 2 cases. In 1 case, attempts at ablation on the left atrial septum also failed.

When the conventional right-sided approach fails to ablate or modify the slow pathway conduction, left-sided ablation can safely and effectively be employed, with success rates and long-term follow-up results comparable to the conventional right-sided approach. (Int Heart J 2005; 46: 1023-1031)

Key words: Atrioventricular nodal reentrant tachycardia, Ablation, Left atrial septum

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ATRIOVENTRICULAR nodal reentrant tachycardia (AVNRT) is the most common form of paroxysmal supraventricular tachycardia, accounting for approximately 60% of adult cases with supraventricular tachycardia (SVT) and radiofrequency (RF) catheter ablation is the preferred method to treat AVNRT in symptomatic patients.¹⁾ Although ablation of the slow pathway at the lower portion of Koch's triangle has a very high success rate, there are cases in the literature in which this approach has failed and success has only been achieved after ablation on the left atrial septum.²⁻⁵⁾ However, little is known about the clinical and electrophysiological characteristics of AVNRT ablated from the left atrial septum. The aim of this study was to evaluate the clinical and electrophysiological characteristics and long-term follow-up results of patients whose AVNRT could only be ablated from the left posterior atrial septum after repeated unsuccessful attempts on the right atrial side and to observe if they differ clinically and electrophysiologically from those patients undergoing successful slow pathway ablation with the conventional right-sided approach.

METHODS

Study population: In 9 of 587 cases (1.5%) who underwent RF catheter ablation for symptomatic typical AVNRT in our electrophysiology laboratory, RF energy delivered to the right posteroseptal, midseptal, or anterosseptal regions with the integrated approach failed to ablate or modify the slow pathway for elimination of AVNRT. These 9 patients were enrolled in the study group (group 1). The remaining 578 patients who underwent successful slow pathway ablation in the same period with the conventional approach served as the control group (group 2). Patients with atypical AVNRT or coexisting different arrhythmias were excluded from the study.

Electrophysiological study and RF catheter ablation: Electrophysiological (EP) study and catheter ablation were performed in a single session in all patients in the fasting, unsedated state and after discontinuation of all antiarrhythmic drugs for at least 5 half-lives. Written informed consent for the EP study and ablation was obtained from each patient. Three multipolar, closely spaced (interelectrode space, 2 mm) electrode catheters were introduced from the right and left femoral veins and placed in the high right atrium, His bundle area, and right ventricle. A steerable decapolar electrode catheter was placed in the coronary sinus to record the electrical activity around the posterior septum and coronary sinus. After the basal measurements, the standard EP study protocol used in our laboratory was performed as reported previously.⁶⁾ AVNRT was diagnosed according to standard criteria.^{1,7,8)}

A Prucka electrophysiology system, Atakr RF generator, and 4-mm tipped ablation catheter (Marinr, Medtronic Inc., Minneapolis, MN) were used for EP study and ablation. Briefly, the ablation procedure was started at the lower margin of the coronary sinus ostium and the catheter was pulled back with continuous RF energy delivery to create a linear lesion with the integrated approach. The sites were considered optimal if the ratio of amplitudes of the atrial and ventricular electrograms was 0.1 to 0.5. Fifty watts of energy with a temperature limit of 70°C was applied at successful sites for 60 to 90 seconds. RF energy was discontinued after 15 seconds when junctional beats were not observed. If this approach failed to eliminate or modify the slow pathway, creation of focal lesions in the coronary sinus ostium or moving the ablation catheter to the mid- and eventually anteroseptal region was attempted, respectively, until ablation endpoints were achieved. If the conventional right-sided techniques were ineffective in eliminating or modifying the slow pathway after about 8-10 RF energy applications, the ablation process was continued with the left-sided approach.

The left atrial septum was reached at the mitral annular level using the retrograde transaortic approach. Intravenous heparin, 5000 IU, was administered before the catheter was introduced into the left ventricle. Ablation success was defined as noninducibility of AVNRT or the presence of no more than a single echo beat with standard stimulation maneuvers in basal conditions and after infusion of isoproterenol.

Follow-up: All patients were discharged on day 2 after catheter ablation without antiarrhythmic medications. They were scheduled for follow-up at intervals of 4-6 months. The long-term efficacy of ablation was assessed using the patients' complaints, 12-lead resting ECG, and when needed, 24-hour Holter monitoring.

Table I. Comparison of Basic Clinical Characteristics of Groups

	Group1 (n = 9)	Group2 (n = 578)	P
Age (years)	40 ± 13	36 ± 15	NS
Male/female (%)	63/37	42/58	NS
Systemic hypertension, n (%)	1 (11)	106 (18)	NS
Diabetes mellitus, n (%)	1 (11)	83 (14)	NS
Structural heart abnormalities, n (%)			
- Valve disease, n (%)	-	75 (13)	NS
- Left ventricular hypertrophy, n (%)	1 (11)	60 (10)	NS
- LVEF < 50%, n (%)	-	45 (8)	NS
Duration of symptoms (years)	7.9 ± 5.5	7.8 ± 7.5	NS
Frequency of palpitations (episodes/month)	2.6 ± 1.0	2.2 ± 1.1	NS

LVEF indicates left ventricular ejection fraction; and NS, not significant.

RESULTS

There were no significant differences between the groups regarding basic clinical characteristics (Table I). Although there was a male predominancy in

Figure 1. A: Intracardiac electrogram during sinus rhythm showing successful site of ablation on the left atrial septum. **B:** Intracardiac electrogram showing junctional beats during radiofrequency energy delivery (hRA indicates high right atrium; CS, coronary sinus; ABL, ablation; ds, distal, and px, proximal).

Figure 2. Fluoroscopic image obtained from left anterior oblique view showing the catheter orientations during slow pathway ablation on the left side of the atrial septum (HRA indicates high right atrium; CS, coronary sinus; and Abl, ablation).

Table II. Comparison of Electrophysiological Characteristics and Results of Radiofrequency Ablation Between Groups

	Group 1 (n = 9)	Group 2 (n = 578)	P
AV node WCL (msec)	362 ± 38	347 ± 29	NS
AV node antegrade ERP (msec)	276 ± 18	263 ± 28	NS
TCL (msec)	366 ± 44	320 ± 29	< 0.001
AH interval during tachycardia (msec)	267 ± 43	215 ± 28	< 0.001
HRA-VA interval (msec)	63 ± 8	68 ± 11	NS
His-VA interval (msec)	24 ± 8	28 ± 11	NS
Dual pathway before ablation, n (%)	5 (55)	392 (68)	NS
Residual dual pathway, n (%)	2 (22)	78 (13)	NS
PR prolongation, n (%)	-	5 (1)	NS
Transient AVB, n (%)		4 (1)	NS
Permanent AVB, n (%)		1 (1)	NS
Isoproterenol for induction, n (%)	2 (22)	145 (25)	NS
Follow-up (months)	37 ± 13	34 ± 11	NS

ERP indicates effective refractory period; HRA, high right atrium; AV, atrioventricular; WCL, Wenckebach cycle length; TCL, tachycardia cycle length; AVB, high-grade atrioventricular block; and NS, not significant.

group 1, it was not statistically significant. No recurrences were seen in the study and control groups in the mean follow-up duration of 34 ± 11 months.

Slow pathway ablation from the left atrial septum: Slow pathway ablation was performed at the posteroseptal aspect of the mitral annulus in 6 cases and the mid-septal aspect in 2 cases after an attempt of unsuccessful right-sided approach. In 1 case, ablation attempts failed on the left atrial septum as well, despite the delivery of more than 10 RF energy applications. Fast pathway ablation was not attempted in any patient before commencing with ablation from the left atrial septum. With the right endocardial approach, junctional beats were observed only with RF energy delivered to the coronary sinus ostium in 4 cases, whereas 4 cases did not exhibit any junctional beats at all. However, junctional beats were observed in all patients during RF energy delivery at the left atrial septum and the A/V ratio was < 0.5 in all attempts at successful ablation. Intracardiac electrograms during sinus rhythm and ablation (Figure 1) and fluoroscopic catheter locations of a representative case (Figure 2) are presented. The average number of RF pulses was 9.9 ± 2.0 , RF duration 455 ± 155 seconds, procedure time 114 ± 23 minutes, and fluoroscopy time 35.9 ± 7.5 minutes. No major complications were noted in any of the patients.

EP characteristics of AVNRT ablated from the left atrium: There were no significant differences between the groups with respect to the baseline sinus cycle length, atrial-His interval, or His-ventricular interval. Also, there were no significant differences between the groups in terms of dual AV nodal physiology: 5 cases in group 1 (55%) had dual AV nodal physiology as compared to 392 patients in group 2 (68%) ($P > 0.05$). However, tachycardia cycle length (TCL) was slightly but significantly longer in group 1 than group 2. The difference in TCL between the groups was mainly due to the difference in AH intervals, which was longer in group 1, as there was no statistical difference with regard to VA intervals between the groups (Table II). The earliest retrograde atrial activation was located in the His bundle electrogram in all patients. Group 1 displayed a higher percentage of patients with residual dual AV nodal physiology in the post-ablation EP study, however, this difference was not statistically significant (22% versus 13%, $P > 0.05$).

There were no significant differences regarding minor or major complications, including transient or permanent atrioventricular block (Table II).

DISCUSSION

Although ablation of the slow pathway at the lower portion of Koch's triangle has a very high success rate of approximately 98%, in about 1% of patients with AVNRT, slow pathway ablation is possible only by targeting the location of ablation to the left atrial septum.^{6,9} Proximity to the target site is the first requisite in successful RF catheter ablation. Thus, in our series of 587 patients with suc-

cessful ablation of typical AVNRT, the fact that slow pathway ablation has only been achieved (using RF success as a marker of pathway location) with the left-sided approach in 8 patients (1.4%) suggests that the slow pathway or the reentrant circuit is oriented toward the left atrial septum in these patients. In a study by Morady, *et al*, AV node ablation could be achieved only with the left-sided approach in about 5-10% of patients with drug-resistant atrial fibrillation, atrial flutter, or tachycardia with rapid ventricular response, which provides further support to the left-sided orientation of the AV node and associated transitional atrial fibers.¹⁰⁾

There are a few observations that might point to the pathophysiological basis of successful ablation of AVNRT on the left but not the right atrial septum. Histological dissection of the atrial septum has revealed an array of transitional atrial fibers from the perinodal area to the septal aspects of both the tricuspid and mitral annuli.¹¹⁾ In addition, it has recently been suggested that there is left atrial input to the AV node.¹²⁾ The transitional zone is a three-dimensional area involving the atrial septum, inner third of the coronary sinus, and posterior left atrium. Moreover, patients with AVNRT have been shown by angiography to have larger cone-shaped coronary sinus ostia as compared to normal controls.¹³⁾ Enlargement of the coronary sinus may orient the posterior inputs leftward in some cases, thus making the left-sided approach mandatory for successful ablation.

Only four reports, in the form of case presentations, have addressed the feasibility of radiofrequency catheter ablation of AVNRT from the left-sided approach to the atrial septum after unsuccessful attempts on the right atrial side.²⁻⁵⁾ Sorbera, *et al*, in their presentation of 3 cases, reported that the TCL and AH intervals of these patients are longer than expected for AVNRT.²⁾ We also observed longer TCL and AH intervals in group 1 compared to group 2. In the present study, observation of the relatively remarkable prolongation of the AH interval for a mean of 50 ms cannot be explained solely by slow pathway localization and/or orientation of the reentrant circuit toward the left atrial septum, and hence creation of an anatomically longer antegrade pathway. The unusually slow conduction behavior of the slow pathway, which makes the antegrade limb of the reentrant circuit, seems to play a greater role in the prolongation of the AH interval.

Different techniques have been used in approaching the left atrial septum for RF ablation. Sorbera, *et al* used the transseptal approach in their series of 3 patients, while Jais, *et al* used a retrograde transaortic approach in their case report and Tondo, *et al* used both transseptal and retrograde techniques in their report of 4 patients.²⁻⁴⁾ Altemose, *et al* used patent oval foramen in their case report.⁵⁾ We used a retrograde transaortic approach instead of the transseptal approach in all patients since none had patent oval foramens, and no major com-

plications were noted.

For left-sided ablation, the posteroseptal aspect of the mitral annulus was mapped with the electrogram-guided approach, as in the traditional right-sided approach. The sites were considered optimal if the ratio of amplitudes of the atrial and ventricular electrograms was 0.1 to 0.5 and if there were fractionated or multicomponent atrial electrograms. In determining the target site for slow pathway ablation, "slow pathway potentials", which are thought to represent the activation of AV nodal transitional cells instead of being a specific marker for the slow pathway atrial insertion site and can be found in any location on the tricuspid annulus, were not specifically sought for.^{14,15} The midseptal region of the mitral annulus was explored when sufficient junctional beats were not observed or procedural endpoints were not reached. With this approach, success was achieved at the posteroseptal aspect of the mitral annulus in 6 cases and midseptal aspect of the mitral annulus in 2 cases.

Since we know that left-sided retrograde atrionodal connections exist, the retrograde fast pathway may have been ablated with the left-sided approach.¹⁶ However, it is more likely (but not proven) that we ablated the antegrade slow pathway because there was no prolongation of the AH interval after ablation in any patient, although the retrograde fast pathway is not necessarily the antegrade fast pathway.¹⁶

It is concluded that, when the conventional right-sided approach fails to ablate or modify the slow pathway conduction, left-sided ablation, preferably with the retrograde transaortic approach, can safely and effectively be employed and that success rates and long-term follow-up results are comparable to the conventional right-sided approach. The left-sided approach may be considered before proceeding with the fast pathway ablation that has higher risk of permanent AV block.

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